OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER

SEEDS: The OARDC Research Enhancement Competitive Grants Program

2014 Report of Progress

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

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For more information, visit the SEEDS website (**oardc.osu.edu/seeds**) or email us at **seeds@osu.edu**.

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SEEDS: The OARDC Research Enhancement Competitive Grants Program

As the research arm of The Ohio State University's College of Food, Agricultural, and Environmental Sciences (CFAES), the Ohio Agricultural Research and Development Center (OARDC) employs nearly 650 scientists and staff members throughout the state. OARDC's Wooster campus is the largest agbioscience research facility in the United States, and OARDC scientists work closely with researchers in Ohio State's Colleges of Education and Human Ecology, Medicine, Public Health, Veterinary Medicine, Biological Sciences and Engineering.

At any given time, OARDC researchers are engaged in more than 400 research projects. These projects are centered around the three signature areas:

- Advanced bioenergy and biobased products
- Environmental quality and sustainability
- Food security, production and human health

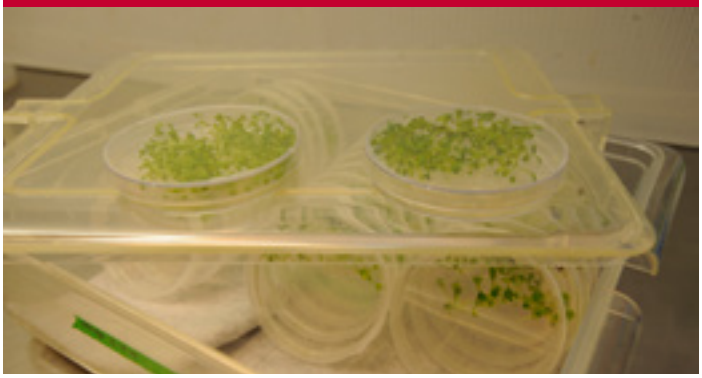
Addressing the differing challenges and vast opportunities of Ohio's agbioscience industry is the ultimate goal of SEEDS: The OARDC Research Enhancement Competitive Grants Program. SEEDS encourages excellence in research by promoting exploration that is consistent with the mission and vision of OARDC and by encouraging connections across disciplines, with industry and with other external partners.

Established in 1996 and supported by OARDC, SEEDS is unique among U.S. state-assisted universities. In fostering high-quality research among scientists supported by OARDC and CFAES, SEEDS enables those scientists to collect the preliminary data needed to give them a competitive edge in national programs. It also provides them with leverage to attract industry support. Due to the changing nature of economic and societal trends, agriculture, food and the green industry depend on innovators and researchers to generate new processes and products. Ohio's largest industry increasingly links with other industries to take on common challenges and opportunities in key areas such as food production and security, energy and the environment, and health and wellness. OARDC's SEEDS program is just one of the many ways in which Ohio State's innovative research and development connect to industry and the community on a global scale.

The following pages will provide a quick glance at the SEEDS objectives and successes. Each faculty project completed in 2014 is included with a brief explanation of the problem being addressed, its importance and the impact of the results. You will also see a sampling of undergraduate and graduate projects, and a list of our industry partners.

For specific information regarding these projects, please contact the faculty members directly or contact SEEDS at **seeds@osu.edu**.

agbioscience: ***the integration of scientific disciplines to address critical needs of food security, safety and health; environmental sustainability; and biobased energy, fuel and products***



Objectives

1. Increase the competitiveness of scientists in extramural grant programs.

Total OARDC funds allocated: $22,647,998

Extramural/Matching funds generated: $120,885,709

Return on investment: $5.34

2. Encourage partnerships with industry and other stakeholders.

Invested
$3.8 million
in projects requiring matching funds, generating
$8 million
in industry matches.

4. Encourage international collaborations.

3. Encourage the development of interdisciplinary teams.

Teams from
10 colleges and
45 departments
were awarded
$7.1 million
in SEEDS funding and reported $23 million in extramural funding—a return of $3.25 for every dollar invested.

5. Provide undergraduate students with research experience.

Funded 59 undergraduate student projects out of 93 submissions.

6. Provide graduate students with the opportunity to take part in the grant-writing/review process.

Funded 239 graduate student projects out of 610 submissions.

2014 In Review

The 24 faculty proposals completed in 2014 represent:

- $1,309,685 invested by OARDC
- $7,187,308 in extramural funds received
- $280,940 in matching funds from industry partners
- 47 publications and 34 presentations
- 12 graduate dissertations/theses
- 2 patents and 1 invention disclosure
- A return on investment of $5.70

Other Accomplishments

Published 891 peer-reviewed scientific manuscripts, abstracts, popular press articles, bulletins and/or book chapters.

Made more than 1,492 presentations throughout the world.

Secured a funding percentage of approximately 42% for faculty proposals.

Produced 67 doctoral dissertations and 100 master's theses.

Obtained 9 patents, 14 invention disclosures and 3 licensing agreements.

Advanced bioenergy and biobased products

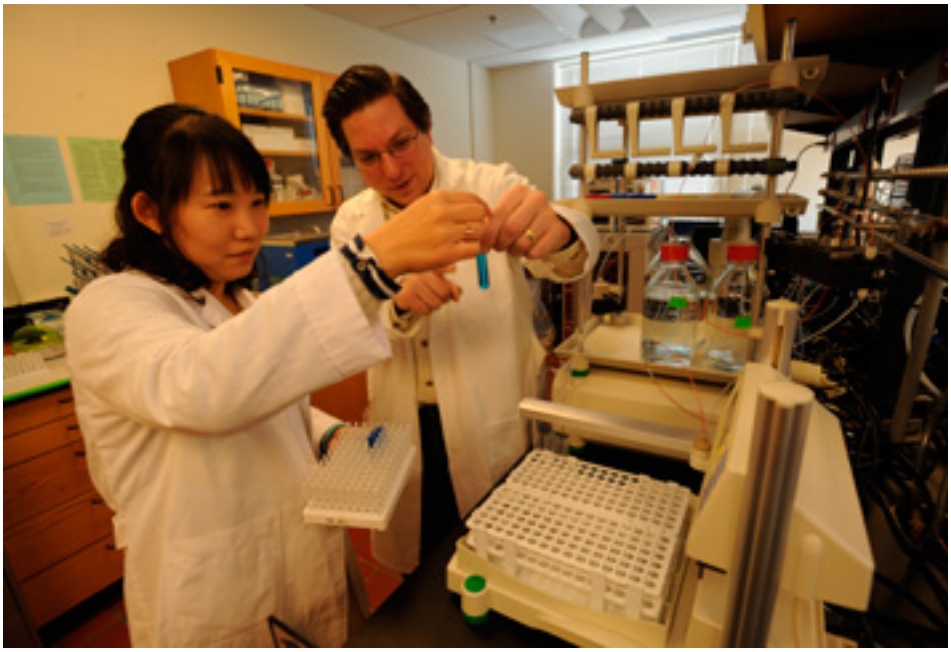
As the importance of renewable sources for energy and materials increases, research and industry partnerships come together in this signature area to develop biomass-based advanced energy technologies and value-added biobased products such as fuels, specialty chemicals and fiber products.

Development and environmental regulation of rubber particles among species

Joshua Blakeslee, Horticulture and Crop Science*
Peter Ling, Food, Agricultural and Biological Engineering
Katrina Cornish, Horticulture and Crop Science/Food, Agricultural and Biological Engineering

Natural rubber is a strategically essential raw material for the United States, which imports approximately 1.2 million metric tons of the material per year. Unfortunately, increased global demand, particularly from the emerging Asian economies of India and China, has resulted in global shortfalls and dramatic increases in natural rubber prices. The state economy of Ohio is particularly dependent on maintaining adequate supplies of natural rubber, as this state is the home of several rubber-based manufacturing companies, including the Cooper Tire and Rubber Company, the Bridgestone Tire and Rubber Company, and the Goodyear Tire and Rubber Company. Development of natural rubber sources that would allow the United States to meet its own natural rubber consumption needs would therefore benefit both the U.S. economy and the state of Ohio.

This project focused on determining the mechanisms by which the rubber-producing plants guayule and *Taraxacum kok-saghyz* (TK; also called Buckeye Gold dandelion, or Russian dandelion) initiate and carry out the synthesis of natural rubber. Researchers completed the development of models using near-infrared (NIR) light to predictively analyze the rubber content of ground TK roots from multiple sample sources. The use of NIR predictive technology was able to reduce the time and resources needed for traditional quantification through accelerated solvent extractions, and should improve the efficiency of breeding efforts designed to increase rubber production. Additionally, the implementation of a hydroponic system for the growth of TK was found to produce adventitious root masses with high regenerative properties and rubber production comparable to soil-grown roots. The hydroponic growth of TK shows promise as a research method and has potential to be employed as a year-round source of root material—through root clipping—for continuous rubber processing. Finally, the researchers developed novel protocols to isolate and characterize proteins involved in rubber synthesis from TK tissues, and they have identified several novel peptides putatively involved in rubber production.



*indicates lead investigator

Environmental quality and sustainability

Work in this signature area seeks to understand, protect and remediate the environment and ecosystems to ensure long-term sustainability. At the core of this effort is the realization that sustaining population and economic growth must be balanced with the preservation of natural resources and environmental assets.

Consequences of hemlock woolly adelgid across riparian and stream ecosystems

Charles Goebel, School of Environment and Natural Resources*
David Apsley, OSU Extension
Mazeika Sullivan, School of Environment and Natural Resources

Introduced species often cause major environmental changes, and they dramatically reshape forest ecosystems in ways we are only beginning to understand. The hemlock woolly adelgid (HWA) arrived in southeastern Ohio in 2011 and is currently causing near complete mortality of eastern hemlock across the eastern United States. This is a significant environmental concern for Ohio as hemlock dominates many of the important natural and recreational areas including the Cuyahoga Valley National Park, Mohican State Forest and the Hocking Hills region. Unfortunately, there is no known treatment to control HWA, and this impending threat to Ohio's forests will be extensive as it is estimated that visitors to Ohio's state parks contribute over $1 billion to the state and local economies. Consequently, it is important to understand the effects of hemlock decline on Ohio's forests so that resource managers and scientists can develop techniques and strategies to help moderate the effects of HWA on hemlock-dominated forests.

A comparison of HWA-infected hemlock stands in Virginia and West Virginia with un-invaded forests in Ohio shows that hemlock is in severe decline in areas where HWA is present. However, hemlock continues to dominate both the overstory and sapling layers of these forests even after 30 years of HWA. Results also suggest that the future forest depends on the current mix of species associated with hemlock or the surrounding forest. The loss of hemlock increases the temperature of the forest floor and nutrient cycling as leaf litter shifts from hemlock to hardwoods. This shift, in turn, is leading to changes in stream-riparian food webs that may affect water quality and aquatic life in Ohio's streams and rivers.

With the assistance of OSU Extension, these findings are being shared with forest managers and other stakeholders in southeastern Ohio. Efforts include training opportunities focusing on hemlock ecosystems, hemlock inventory, HWA survey methods and HWA management strategies. These efforts have reached approximately 800 individuals at more than 20 events. Monitoring will continue in order to refine predictions about forest development and extend efforts to focus on how HWA influences downed wood located both in and along streams.

Integration of small ruminants into organic cropping system

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Steve Loerch, Animal Sciences
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Carrie Pickworth, ATI
John Cardina, Horticulture and Crop Science
Jefferson McCutcheon, OSU Extension

Sheep and goats are natural livestock choices for a sustainable organic system. They are small, tend to be hardy and are easily handled. They can be managed on a grazing system—with minimal grain supplementation—and used to glean post-harvest crop fields. Sheep primarily consume forages, but they are known to eat 90 percent of weed species and are increasingly being used as biological tools for resource management to control weeds. Organic sheep production is currently limited because of national standards associated with the control of gastrointestinal parasites. Grazing sheep in annual crop fields may provide excellent nutrition for the animals, may break up the parasite life cycle and may reduce the need for dewormers. This leads to the possibility of using sheep in an integrated organic annual cropping and pasture farming system, as grazing sheep may help manage the weed pressure typically found under organic conditions.

The objective of this study was to determine if sheep would eat weeds growing in organic crop fields after crop harvest, and specifically if they would eat giant ragweed. Results showed they will eat most weeds present in crop fields after harvest, including giant ragweed, lambsquarter, foxtails, Pennsylvania smartweed and wood sorrel. The amount they eat increases—and dietary choices decrease—at higher stocking densities.

Preference of fungus gnats for soilless propagation media

Luis Canas, Entomology*

In Ohio, many greenhouse operations use a variety of propagation media to start their plants. This can be problematic if the media is contaminated with fungus gnats. Adult fungus gnats are nuisance pests, but the larvae can damage plant leaves when they are in contact with plant propagation media. Thus, the contact reduces the economic value of the plants produced. Adults prefer to lay eggs in very moist areas, so the choice of propagation media is crucial to avoid major problems with these insects. Many facilities use propagation media produced by Smithers Oasis, an Ohio-based company that is a leader in the production of plant propagation foam heavily used in the ornamental industry. Finding the propagation media preferred by fungus gnats will help adjust or modify management tactics to keep plants clean.

This project evaluated the preference of fungus gnats for soilless plant propagation media from various industry producers including potting soil, hardwood mulch and Smithers Oasis media. This experiment showed that potting soil and hardwood mulch are heavily preferred by fungus gnat females for laying eggs, although it is possible for the fungus gnat adults to lay eggs in Oasis media. Future research should examine whether fungus gnat eggs could hatch and live in Oasis media.

Developing best field management strategies for control of bacterial diseases on processing tomatoes

Erdal Ozkan, Food, Agricultural and Biological Engineering*
Sally Miller, Plant Pathology
Richard Derksen, Food, Agricultural and Biological Engineering/USDA

The principal objective of this project was to help Ohio tomato growers minimize tomato yield loss from bacterial diseases by identifying economical and effective production strategies with a special focus on the equipment used to apply bactericides to protect plants against bacterial diseases.

An interdisciplinary team of researchers conducted this study to determine the most effective spray equipment methods for applying bactericides to tomatoes for the purpose of controlling bacterial disease. However, the results obtained from this study may be applicable to controlling several other diseases of tomatoes that also require thorough coverage of the plant canopy. The ultimate goal is to reduce production costs through reduced pesticide consumption using the most appropriate spraying equipment while maximizing the quality and quantity of tomato produced.

MCIC Galaxy: A web-based platform for high-throughput sequence data integration and analysis

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Omprakash Mittapalli, Entomology
Stephen Opiyo, Molecular and Cellular Imaging Center
Kun Hung, Biomedical Informatics

This project aimed to develop computational software for large sequence dataset analysis for scientists to survey whole genomes and address complex biological problems in food, nutrient and agriculture at the MCIC Computational Biology Laboratory (MCBL). We developed a biologist-friendly centralized web-based portal (Galaxy site) that hosts a variety of bioinformatics tools for genetic data analysis and handling. It also makes the execution of complex, multistep data-mining process, sharing and access relatively easy and fast. Specifically, this site contains software for quality controls and preprocessing of sequence data; various mapping algorithms to align sequence reads to reference genome; read count-base and statistical software for gene expression analysis; de novo genome assemblies from transcriptome or genomic data; NCBI Blast tools; sequence annotation tools; and several workflows for automated and customized data-mining. Online tutorials and hands-on class trainings have also been developed for users on how to execute the various steps of particular workflows or pipelines.

Effects of catastrophic natural disturbance on the structure and function of forest ecosystems

Charles Goebel, School of Environment and Natural Resources*
John Cardina, Horticulture and Crop Science

Natural disturbances are processes that significantly alter ecosystems. One of the most important disturbances affecting forest ecosystems is wind, influencing forest regeneration and development at both local and regional scales.

On September 16, 2010, the OARDC campus experienced such a natural disturbance, as an EF-2 tornado with winds ranging from 179–217 kph left a path of destruction over 19 km long. With winds similar to that of a Category 3 hurricane, the damage to the OARDC campus was severe, with large portions of the 54-ha Secrest Arboretum heavily impacted, including many of the gardens and landscape plantings. The natural forested areas were also heavily impacted, with many trees blown over or experiencing basal shear. The storm, however, provided a unique research and educational opportunity to study how forest ecosystems develop following a major yet infrequent natural disturbance.

Researchers compared plots within the tornado-impacted area to undisturbed locations and discovered that while the tornado caused heavy damage to the overstory trees, the tornado had very little impact on the understory plant communities. These areas will be monitored for invasive and non-native species which could affect the understory as well as the insect community that are good indicators of ecosystem health. For example, following the tornado, more spiders and fewer ground beetles were uncovered in the tornado-damaged area.

Educational materials and signs are being developed for Secrest Arboretum to explain the importance of natural disturbances to forest ecosystems and how that information can be used to guide future restoration and management efforts.

Investigating aquatic-to-terrestrial contaminant flux in the Scioto River Basin

Mazeika Sullivan, School of Environment and Natural Resources*

Interest continues to grow in the potential for contaminants in aquatic systems to move into terrestrial ecosystems through animal movement (e.g., insects, birds, reptiles). In particular, the consumption of aquatic-emergent insects (i.e., larval insects that emerge from the water as winged adults) may be an important mechanism of contaminant flux across ecosystem borders. Understanding the causes and consequences of contaminant transfer between aquatic and terrestrial systems is critical in Ohio's changing landscapes, where streams and rivers are threatened by pollution from a suite of human activities.

Results of this study revealed that land use and land cover (LULC) can be strong determinants of aquatic-to-terrestrial contaminant transport. This research has improved the understanding of the pathways and influences that control aquatic-to-terrestrial contaminant transport and will be used to inform risk management and remediation approaches.

Understanding native lady beetle decline in North America

Andrew Michel, Entomology*
Mary Gardiner, Entomology

One objective of this project was to characterize the decline among populations and species of native lady beetle and evaluate the influence of landscape modification on genetic diversity. Collections were done by sweep net in alfalfa fields in 13 states in the Midwest region of the United States, including Ohio. Eight lady beetle species were collected at these sites: four native species, and four exotic species. A total of 2,341 beetles were collected for gut content and population-genetics analysis. DNA-sequencing analysis is ongoing.

Another objective was to engage the public in citizen science programs to conduct an annual survey of lady beetle abundance within residential landscapes across Ohio. More than 500 individuals have been trained in lady beetle sampling and identification.

Food security, production and human health

This signature area focuses on improving agricultural production; enhancing the quality of food and feed; ensuring an adequate, affordable and safe food supply; and maintaining agrosecurity to ensure food security and the basics of nutritional health for a growing global population.

Understanding the evolution and pathology of wheat blast disease

Thomas Mitchell, Plant Pathology*
Pierce Paul, Plant Pathology

Plant diseases are one of the main limiting factors in crop production worldwide, causing billions of dollars in yield loss and tremendous historical human suffering and migrations. The two most important agricultural crops in the world are wheat and rice. Availability of these two grains historically has more impact on human health, regional economic stability and social rest than any other crop. One of the most important diseases of rice is rice blast, caused by the fungal pathogen *Magnaporthe oryzae*. Significantly, *Magnaporthe* has jumped to become a pathogen of wheat in South America causing wheat blast disease. Currently, wheat blast is present in all major wheat-growing regions of Brazil and surrounding countries, with a major outbreak in 2009 that pushed losses over 40 percent in many parts of the country.

While the impact of this disease in South America is acute, there is every expectation that it will continue to move north and dramatically affect U.S. wheat fields. Significantly, the pathogen was found in Kentucky three years ago. The goal of this project was to elucidate how this fungus gains entry into its host and the basic etiology of infection, screen Ohio wheat germplasm for susceptibility to the pathogen, and to use genomics to begin to understand the origin of the pathogen in Brazil and how to detect it. Towards that goal, the genomes of two isolates of the wheat blast pathogen from Brazil were sequenced and analyzed. The analysis revealed that the pathogen most likely did not originate from the rice-infecting versions of the fungus, but rather a ryegrass-infecting version. This result was revealed after collaboration with investigators at the University of Kentucky and Kansas State University. These genome data were the first sequences available for this pathogen and have now been combined with a new larger national effort to understand its origin and develop detection methods. Results from screening soft, red winter wheat suggest that some cultivars may only be partially resistant to the pathogen and may pose a threat to production in the United States if conditions are conducive.

This study sought to identify highly resistant and susceptible varieties of wheat for use as future reference groups; elucidate how the fungus penetrates and infects the plant; and identify genes that the fungus may use during the infection process.

Anti-inflammatory effects of green and black tea in the gastric epithelium

Joshua Bomser, Human Nutrition*

Despite reductions in gastric cancer mortality in the United States, gastric cancer remains the second most commonly diagnosed cancer worldwide. The goal of this research was to identify dietary compounds that can reduce inflammation and uncontrolled growth associated with cancer development. Increased consumption of tea as well as other plant products containing a variety of phytochemicals may be associated with decreased risk of cancer.

Plant, cellular and molecular biologists may have the ability to exploit these data to develop tea-related products and applications that will enhance the Ohio economy. Specifically, this research was aimed at understanding basic mechanisms by which dietary components can reduce inflammation and associated disease progression. These combined research efforts are ultimately designed to reduce chronic disease, improve quality of life and provide economic stimulus that will allow for sustainability and growth of these very important scientific programs.

Research has found that phytochemicals found in tea and other plant-based foods can reduce the growth of cancer cells in vitro by disrupting the way in which these cells utilize energy. Future work may be related to expanding these findings in a clinical setting in order to understand how dietary compounds can disrupt energy utilization in vivo and therefore reduce disease risk, especially those chronic diseases involving inflammatory processes.

Potential for replacement of dietary fishmeal protein with an improved variety of soybean for the intensive culture of yellow perch

Konrad Dabrowski, School of Environment and Natural Resources*

Expected to become commercially produced in intensive aquaculture systems, yellow perch is one of the major fish species in the Great Lakes region. The cost of feed, particularly of fish meal, is decisive in respect to profitability of perch culture industry. Therefore, this project examined the effect of a fishmeal replacement with soybean meal obtained from a particular, genetically selected variety of soybean (Schillinger Genetics, IA) on growth and diets utilization in yellow perch.

Results suggested that replacing 75 percent of fish meal in yellow perch diets with Schillinger soybean meal appears feasible and economically beneficial. This research must be expanded in the future to include histopathological analysis of the pancreas and posterior intestine following long-term feeding diets with high proportion of soybean proteins.

Development and use of a purpose-built data acquisition system to measure bumblebee foraging activity and efficiency

Mary Gardiner, Entomology*

The common eastern bumblebee (*Bombus impatiens*) has experienced significant population declines throughout the north central United States. These declines have been linked to factors including disease, habitat degradation and pesticide exposure. Bumblebees provide significant pollination to crop plants; yet the majority of studies evaluating the lethal and sublethal impacts of pesticides on bees have focused on honeybees.

Recently, it was revealed that both the active ingredients within pesticides and the adjuvants added to improve their effectiveness are potentially hazardous to honeybees, but research has not extended to bumblebees. Dr. Gardiner and her industry partners developed a purpose-built data acquisition system to address this important research area. This system used radio frequency identification (RFID) tags and readers to compare foraging trip-timing and duration by bumblebees exposed to an organosilicone surfactant adjuvant alone, or in combination with an herbicide. In our region, 2,4-D-tolerant field crops are expected to be released within the next three years, increasing the likelihood of pollinator exposure to these compounds. Thus, understanding their impact on pollinator foraging efficiency is of critical importance.

Four colonies of bumblebees were established, with each one receiving a different treatment. Bees were tagged with a unique RFID tag, and the colonies were placed within the data acquisition system. Results showed reduced hive growth in colonies exposed to the herbicide or adjuvant alone or in combination relative to the control hive. These results illustrate that exposure to 2,4-D herbicide with or without an adjuvant does have a negative impact on colony growth. This resulted not from a reduced number of foraging trips, but from a reduction in the amount of provision collected per trip. Therefore, exposed bees may be less effective pollinators of the flowers they visit within the surrounding landscape.

Enhancing bioavailability and nutritional quality of processed tomato products

Steven J. Schwartz, Food Science and Technology*
Gregory B. Lesinski, Medical Oncology

Diet has been shown to play a crucial role in one's risk for developing cancer. Epidemiological evidence suggests that people who consume diets rich in fruits and vegetables, and more specifically, rich in tomatoes and tomato products may experience a decreased risk for developing certain cancers. Lycopene has received the most attention for this noted decrease in cancer risk from tomatoes. Most of the lycopene in fresh tomato and processed products exists in a linear configuration, as all-trans-lycopene. However, lycopene circulating in the body of people consuming a tomato-rich diet exists primarily in a bent form, as cis-lycopene.

Tangerine tomatoes are unique, orange-colored tomatoes produced using conventional breeding techniques. These tomatoes are unique in that they accumulate cis-lycopene instead of all-trans. Interestingly, tangerine tomatoes also physically deposit lycopene differently (as lipid droplets) from red tomatoes (as crystals). Tangerine tomatoes from this trial were a hybrid variety developed at Ohio State to thrive in Ohio and to withstand machine-harvesting.

In order for lycopene to exert beneficial health effects in the body, it must be absorbed and it must reach sites where it could potentially act. Comparing red and tangerine tomatoes offers a way to understand how isomer profile (all-trans versus cis) and physical deposition form affect lycopene bioavailability. Researchers conducted a human clinical trial where each subject consumed both red and tangerine tomato juice on different days, and the appearance of carotenoids in triglyceride-rich lipoprotein (TRL) fractions of plasma were monitored over time. On average, subjects absorbed 8.5 times more lycopene—a marked difference—from tangerine tomato juice when compared to red tomato juice. This work provides valuable insight into absorption of cis-lycopene from lipid-dissolved droplets and will help inform future human clinical trials investigating tomato/lycopene-based chronic disease prevention.

Systems-level analysis of Stewart's wilt disease in maize

David Mackey, Horticulture and Crop Science*
Kengo Morohashi, Center for Applied Plant Sciences
Guo-Liang Wang, Plant Pathology

Stewart's wilt disease limits production of sweet and field corn in the central and eastern United States and is caused by the bacterial pathogen *Pantoea stewartii* (Pnss). The ability of Pnss to cause Stewart's wilt is dependent on a key virulence factor called WtsE; mutant strains of Pnss lacking WtsE fail to proliferate or cause disease symptoms in maize. WtsE is a type of virulence factor that is delivered by the bacteria through a hypodermic needle-type structure into the cells of host plants where it is active. Thus, a key to limiting the negative consequences of Stewart's wilt disease is gaining a thorough understanding of how WtsE perturbs the host cells, into which it is delivered, to promote susceptibility.

This research on the integrated transcriptomic and metabolomic shifts during the maize-Pnss interaction have linked changes in gene expression and consequent production of metabolites to the resistant or susceptible outcome of infection. Future research will inform breeding efforts and agricultural practices to enhance productivity of maize, tomato, apple and pear trees, and other crops plagued by bacteria deploying WtsE and related virulence proteins.

Discovery and validation of molecular targets in the Malpighian (renal) tubules of mosquitoes

Peter Piermarini, Entomology*

The Asian tiger mosquito is a known or suspected vector of several medically important viruses around the globe, including those that cause chikungunya, dengue, yellow and West Nile fevers. These viruses are transmitted to humans when an infected adult female mosquito feeds upon them. Moreover, the Asian tiger mosquito is one of the most invasive mosquito species in the world and has spread to at least 36 states in the United States, including Ohio.

Existing control measures for mosquitoes typically focus on the use of insecticides that target their nervous system. However, resistance to these insecticides is limiting our ability to control mosquitoes. Thus, to limit the spread of mosquito-borne diseases, it is necessary to identify novel physiological targets in the mosquito to guide the development of new insecticides. The Piermarini laboratory has recently demonstrated that the “kidneys” (Malpighian tubules) of mosquitoes are a valuable physiological target for insecticide development that has not yet been exploited. However, it is still poorly understood how this tissue contributes to vital biological processes in mosquitoes, such as the metabolic processing of blood meals.

The goal of this project was to address this gap in our knowledge by characterizing the changes in gene expression that occur in the Malpighian tubules of adult female Asian tiger mosquitoes after they consume a blood meal with the goal of identifying key molecular pathways that are activated. These activated pathways may represent valuable targets for new insecticides that would disrupt the renal functions of mosquitoes and limit the number of blood meals they could take in their lifetime, thereby limiting their potential to spread mosquito-borne diseases.

There were dramatic changes in the expression of genes in the Malpighian tubules of the Asian tiger mosquito after they fed on blood. In particular, a concerted increase in the expression of genes associated with the detoxification and excretion of metabolites associated with blood digestion was found, suggesting a previously undiscovered role of the Malpighian tubules in the metabolic processing of blood meals. Researchers are presently attempting to suppress the expression of these genes to verify that they play critical roles in blood meal processing, which would validate them as a new target for insecticide development.

A novel approach to plant protection through durable systemic resistance

Parwinder Grewal, Entomology*

Entomopathogenic nematodes (EPNs) are well known as biological control agents for soil-inhabiting insect pests. Extra benefits from these agents are expected based on previous observations that soil application of EPNs has direct antagonistic effects on root-knot/foliar parasitic nematodes and indirect effects on pests through the activation of defense mechanisms in hosta and *Arabidopsis thaliana* leaves.

This project explored the feasibility of using EPNs in induction and maintenance of the systemic resistance in tomato. We applied *Steinernema carpocapsae*-infected wax moth (*Galleria mellonella*) cadavers to the soil around the roots of tomato plants, and those receiving the freeze-killed cadavers served as the controls. After 3, 7 and 15 days of the treatment (DAT), leaf bioassays were conducted to assess the effects of treatments on the development of insect herbivores and pathogens. Results confirmed the hypothesis that soil application of EPNs carries durable benefit to the tomato plants by enhancing their defensive capability. Thus, this study has the potential to lead to the development of practical approaches for inducing and maintaining systemic resistance for extended periods in economically important plants against diverse pests and pathogens.

Genetic improvement of SMD-utilization efficiency by developing indirect criteria for RFI in yellow perch

Hanping Wang, OSU South Centers*
Laura Tiu, OSU South Centers

Aquaculture has an estimated economic impact of $49.5 million in Ohio, and yellow perch is the number one, high-value aquaculture species in Ohio. As fish meal production decreases, aquaculture represents a great potential for the use of soybean meal as a protein replacement in aqua-feeds. Residual feed intake (RFI) is the trait that is now broadly used to study the feed-utilization efficiency in animals. Because fish are raised in groups, individual feed intake cannot be measured directly. Therefore, indirect criteria for RFI are strongly needed for aquaculture breeding programs to improve soybean meal diet (SMD)-utilization efficiency and select strains more amenable to soybean- based protein.

The outcomes contribute to the establishment of the improvement program by producing superior broodstock of yellow perch with the traits of better growth and SMD feed efficiency for aquaculture farmers. The indirect criteria for improving feed intake of SMD will be used for genetic improvement programs for other fish species also to improve SMD-utilization efficiency. The long-term impacts of this project will be primarily via the delivery of superior yellow perch strains with higher growth and SMD utilization rates to fish farmers in Ohio and the Midwest. The greatest return on investment for this project is the ultimate reduction in production costs due to increased growth rate and reduced feed costs by using SMD through genetic improvement. If success in this initiative is similar to that achieved for other fish such as trout, catfish and striped bass, this type of genetic selection should improve growth by 20–25 percent and feed efficiency by 5–10 percent per generation. As Ohio aquaculture grows and technique improves for using soy, the soybean consumption will greatly increase in Ohio and the Midwest for aquaculture purposes.

Characterization of emerging human and porcine rotaviruses and investigation of immune responses

Anastasia Vlasova, Food Animal Health Research Program*
Linda Saif, Food Animal Health
Kuldeep Chatta, Food Animal Health

Rotaviruses (RVs) are the leading cause of acute viral gastroenteritis in children, causing about 660,000 deaths annually worldwide, but with most (90 percent) in Africa and Asia. New live rotavirus (RV) oral vaccines and monovalent Rotarix are licensed and have pooled efficacies of 85 percent and 73 percent, respectively, in developed countries. However, prior studies in developing countries confirmed a dramatically reduced pooled efficiency of only 51 percent and 20 percent, respectively. For infants, high susceptibility to infections and immunologic immaturity pose universal concerns for vaccine development.

Likewise, RV diarrhea is common and costly in nursing and weaned pigs, and the efficacy of commercial live oral RV vaccines is low. Thus, it is important to evaluate the efficacy of RV vaccine candidates and to assess cross-protective potential of dominant RV strains in the gnotobiotic (Gn) piglet model. The long-term goal of this project was to improve the efficacy of oral vaccines in infants in impoverished countries, and in neonatal pigs.

Herbicide volatility, spray drift and the vineyard

Douglas Doohan, Horticulture and Crop Science*
Imed Dami, Horticulture and Crop Science
Roger Downer, Horticulture and Crop Science
Jason Parker, Horticulture and Crop Science

Grape is one of many specialty crops grown in Ohio and has become the fastest growing sector in Ohio agriculture. Meanwhile, stakeholders in the grape industry are convinced the sustainability of their enterprise is threatened by the imminent use of 2,4-D and dicamba herbicides on new genetically modified (GM) field crops that will be commercially available starting in 2015.

In fact, strong and opposing opinions regarding increased use of 2,4-D and dicamba to control weeds in new GM herbicide-tolerant trait crops is an intense controversy in Ohio and throughout the Midwest. Proponents view these new herbicides as essential to managing resistant weeds, while opponents are concerned about crop damage from spray drift.

This study aimed to characterize the risk to the Ohio grape industry posed by these new herbicides by studying five common varieties of grapes. Vinifera varieties suffered severe damage from doses only 1/100th–1/300th the rate that will be used on soybeans and corn. Hybrid varieties are less susceptible, but still suffered damage. The use of 2,4-D caused the greatest damage. Grape vines were also very sensitive to dicamba though somewhat less so than 2,4-D.

High-pressure processing of vegetables: Formation, stability and bioaccessibility of folates

V. M. (Bala) Balasubramaniam, Food Science and Technology/Food, Agricultural and Biological Engineering*
Steven Schwartz, Food Science and Technology
Kenneth Riedl, Food Science and Technology

Folate, also known as vitamin B9, is a water-soluble vitamin that is synthesized by plants and microorganisms. In humans, folate is an essential nutrient obtained from the diet. It boasts preventative properties against several chronic diseases, and a link has been established between pregnant women who have sufficient intake of folate and lower risk of neural tube defects in newborns.

High-pressure processing is a novel food processing technique that involves the use of pressures up to 600 MPa in order to inactivate microorganisms and extend the shelf life of products. Application of pressure reduces the thermal exposure of the food during processing, thereby protecting a variety of bioactive compounds. Pressure treatment at ambient or chilled temperatures has minimal impact on product chemistry.

The objective of this study was to determine the effect of refrigerated and frozen storage after high-pressure processing on the 5MTHF polyglutamate species distribution and total 5MTHF content in broccoli. In conclusion, the high-pressure processing was able to convert polyglutamyl 5MTHF to more bioavailable monoglutamate forms and the benefit was maintained during refrigerated and frozen storage.

Comparison of vaccines for the control of very virulent infectious bursal disease viruses

Daral Jackwood, Food Animal Health Research Program*

The very virulent infectious bursal disease virus (vvIBDV) was first identified in the United States in 2009. Since then, it has been detected in California and Washington and is a threat to the U.S. poultry industry. These viruses could be economically devastating for the U.S. poultry industry because of the 20–60 percent mortality associated with this acute disease. Vaccines available in the United States have not been tested for efficacy against this highly pathogenic strain of the virus. This project examined the efficacy of two IBDV vaccines for their ability to protect broiler chickens against vvIBDV.

A classic IBDV vaccine complexed with antibody was compared to an HVT-IBDV recombinant vaccine in maternally immune broilers. The results indicated that both vaccines protected the broilers, but only to a limited extent. The vvIBDV challenge virus was able to infect birds vaccinated with both products, and it was able to cause histopathologic lesions that are consistent with immune suppression.

Future studies will examine other commercially available vaccines for their ability to protect against and stop the spread of vvIBDV.

Nematode susceptibility in *Arabidopsis*

Christopher Taylor, Plant Pathology*

Significant progress has been made in understanding the immunity systems of plants against pathogen attack. Phytohormones such as jasmonic acid (JA) and salicylic acid (SA) regulate plant defenses. JA and SA-activated signal transduction pathways are mutually antagonistic and regulate the finely tuned production of defense proteins and compounds tailored to plant pathogens. Most experiments utilized above-ground portions of plants, and little is known about how these pathways interact in the root.

An important pathogen of the root are root-knot nematodes, which are capable of reproducing on over 2,000 species of plants and responsible for approximately $50 billion in damage to agronomic crops annually. Root-knot nematodes create a specialized feeding site requiring extensive remodeling of the root. Little is known about the role of specific defense-related hormones (i.e., JA and SA) in the susceptible response.

This project has helped improve our understanding about the nematode-parasitism process. These findings combined with other findings from the laboratory have enabled the Taylor laboratory to obtain additional funding from companies who are utilizing the newly found knowledge to design new strategies for nematode control.

Developing resistance to *Xanthomonas gardneri* in processing tomatoes

David Francis, Horticulture and Crop Science*

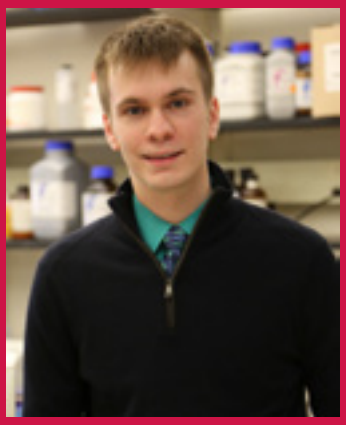
Bacterial spot of tomato is a major threat to tomato production wherever summer rains occur. It causes yield and quality losses from defoliation and fruit lesions. Chemical control is ineffective and adds to the environmental and production cost beyond loss of yield and quality. Developing tomato varieties resistant to this disease could offer an effective way to control the problem and avoid major crop losses for tomato growers.

Three potential sources of resistance were discovered, and genes conferring resistance were localized to one of tomato's 12 chromosomes. Two hundred forty processing and fresh market lines as well as 93 wild species relatives were tested for resistance to *X. gardneri*. One of the wild species accessions had a significant decrease in the number of bacteria found in inoculated leaves based on comparison to susceptible controls. In order to develop lines with commercial characteristics and resistance to the disease, populations were developed for simultaneous breeding and genetic studies. These populations were combined with information on DNA sequence variation in order to identify the chromosome segments conferring resistance.

Student Projects

The Director's Undergraduate Research Competitive Grants program, funded to a maximum of $3,300 per award, provides undergraduate students with a professional grant-writing, research and reporting experience. Projects are designed, submitted for review and carried out with a faculty mentor.

The Graduate Research Competitive Grants program offers two levels of funding. Doctoral students may receive up to $5,000 per award, and master's students up to $3,000. Team projects consisting of multiple students are also allowed. Graduate students who receive awards are asked to serve on a panel to review applications in the following year's competition. This experience provides students with an opportunity to develop their grant-writing and reviewing skills, which are essential to their careers.



Logan Pfeffer

Stephanie Verhoff

Kayla Perry

Ellie Walsh

Wendong Zhang

Antibiotic resistance in conventionally vs. organically raised cattle (UNDERGRADUATE)

Logan Pfeffer, Microbiology
Hua Wang (Advisor), Food Science and Technology

The emergence of antibiotic-resistant (AR) pathogens poses a serious challenge for healthcare professionals and to public health in general. As more pathogens are becoming resistant to antibiotics, current antibiotic treatments are being exhausted. It is important to preserve the effectiveness of current antibiotic medications by mitigating the dissemination and propagation of antibiotic-resistance genes. It is also important to identify sources of AR genes and AR gene amplification in the environment not only for pathogenic bacteria, but for commensal microorganisms as well. Prior studies have shown that livestock animals are major reservoirs for AR genes and are sources of AR gene amplification in the environment. The goal of this study was to investigate the prevalence of AR bacteria and AR genes in cattle raised on both organic and conventional farms to provide a better understanding of AR commensal micro flora in cattle raised on each type of farm.

In this study, fecal, feed and water samples were taken from both a certified organic cattle farm and a conventional cattle farm around central Ohio. These samples were then screened for bacteria that are resistant to four different types of antibiotics. Higher populations of AR intestinal bacteria were recovered from conventionally raised cattle than organically raised cattle. However, despite the consistent difference in the recovered intestinal-AR bacteria populations, there was no significant difference in the amount of AR bacteria recovered from food and water samples from the organic and conventional farms except for the conventional water sample. This sample was consistently lower than the other three food and water samples. Multi-drug resistance, resistance to multiple antibiotics, was detected in all of the samples analyzed; however, samples from the conventional farm consistently had a higher percentage of multi-drug resistant isolates compared to corresponding organic samples.

Pollen limitation of seed set in small populations of *Miscanthus sinensis*, an ornamental grass with invasive potential (UNDERGRADUATE)

Stephanie Verhoff, Horticulture and Crop Science
Allison Snow (Advisor), Evolution, Ecology, and Organismal Biology/Kristin Mercer (Advisor), Horticulture and Crop Science

Miscanthus sinensis (Chinese silvergrass) is a perennial grass native to Eastern Asia. Ornamental cultivars of *M. sinensis* are popular in Ohio and elsewhere, and may give rise to invasive populations. Naturalized (feral) populations already exist in 25 states in the United States, with the potential to spread further; yet few studies have focused on the reproductive ecology of this non-clonal, self-incompatible (inability to self-fertilize) grass. It is vital to understand the stages of invasion in order to prevent economic and environmental costs due to the management of invasive species and the displacement of native species. For example, each year $125 billion is spent on the management of nearly 50,000 non-indigenous species. Many studies are focused on current invasive species, ignoring the introduction and naturalization steps that occur before invasion. Often there is a “lag phase” between initial escape and establishment. A better understanding of this lag phase may help determine a critical threshold size for populations. This would increase efficiency of future management strategies by determining when and how much action is needed, thus saving resources.

The goal of the study was to determine whether seed production in feral *Miscanthus* populations is limited by available pollen from nearby individuals. Flowering shoots from nine populations of varying size and population density in Ohio and West Virginia were sampled. Results showed an increase in percent seed set as population size increases. Overall, the results suggest that pollen-limited seed set was common. This finding supports the hypothesis that rates of invasion of *M. sinensis* may go through an initial lag phase until sufficient pollen is available to allow substantial seed production in newly established populations.

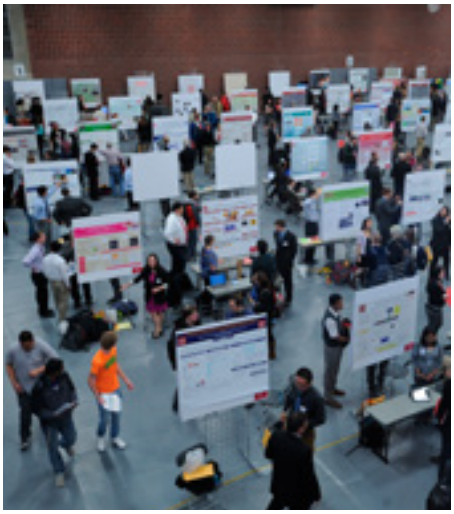
Effects of ash mortality caused by emerald ash borer on the forest floor invertebrate community (MASTER'S)

Kayla Perry, Entomology
Daniel A. Herms (Advisor), Entomology

Emerald ash borer (EAB; *Agrilus planipennis*) is an invasive wood-boring beetle that has killed untold millions of ash trees in eastern North America. Formation of canopy gaps is a natural process in forests, but the widespread, nearly simultaneous formation of canopy gaps from EAB is an unprecedented phenomenon. Ash species are common throughout eastern deciduous forests, and The Ohio Department of Natural Resources estimates that one of every 10 trees in Ohio's forests is an ash. Therefore, disturbance caused by emerald ash borer-induced tree mortality has the potential to cause significant ecological and economic impacts throughout forests in Ohio and elsewhere.

Canopy gaps caused by EAB-induced ash mortality increase light availability and alter environmental conditions on the forest floor. Gaps have the potential to affect the abundance and diversity of ground-dwelling invertebrates, including insects and spiders that are key regulators of ecosystem components and processes. As dead trees fall, accumulation of logs and branches on the forest floor also alters biodiversity and ecosystem processes. The effects of disturbance on invertebrate diversity will likely have cascading effects throughout the forest food web as they are a resource for species, including other arthropods, amphibians, reptiles, birds and small mammals. In the absence of a functionally diverse forest floor invertebrate community, these critical ecosystem services would cease to exist with direct implications for forest sustainability and management.

This research investigated the effects of canopy gaps caused by emerald ash borer and ash logs on the forest floor invertebrate community via a manipulative experiment conducted in natural areas at NASA's Plum Brook Research Station in northern Ohio. Canopy gaps decreased invertebrate diversity and altered community composition by reducing the abundance of predators, decomposers and other essential functional groups on the forest floor. However, the addition of ash logs did not affect the forest floor invertebrate community. This suggests canopy gaps created by EAB-induced ash mortality will have indirect ecological impacts on forest structure and function beyond the obvious direct effects of tree mortality.



The influence of parasitic interactions on host gene silencing (DOCTORAL)

Ellie Walsh, Plant Pathology
Christopher Taylor (Advisor), Entomology

Plant-parasitic nematodes are microscopic round worms that can cause serious damage to agricultural crops. One economically important group of plant-parasitic nematodes is the root-knot nematode. Root-knot nematodes induce knot-like formations on infected plant roots that disrupt the plant's ability to uptake water and mineral nutrients from the soil. Young root-knot nematodes enter the roots of plants and select a handful of cells from which to feed. Using a mixture of secretions released from their stylet (a straw-like mouthpart), the nematode is able to trick the plant into creating the feeding site. This feeding site consists of several plant cells that enlarge (also called giant cells) and provide the nematode with

all the nutrients it needs to produce hundreds of eggs. In order to better understand how the nematode is tricking the plant into creating the feeding site while avoiding plant defenses, this project set about to discover what pathways in the plant are being manipulated by the nematode.

One important set of pathways investigated were the plant's gene-silencing pathways, named such because they can silence, or turn off, genes. These pathways are responsible for regulating a number of different responses for the plant, including its response when attacked by other pathogens. A potassium channel gene that is normally down-regulated actually increased in expression in the nematode feeding site. This suggests that the nematode may be interfering with the gene-silencing pathways, resulting in the over-expression of genes that could be essential to nematode parasitism. While this work has produced some new lines of evidence that root-knot nematodes interfere with these gene-silencing pathways while they feed on the plant, more research is needed to determine whether this interference is truly vital for a successful nematode infection. If this can be determined, we will be able to improve our options for nematode control.

From management decisions to watershed environmental quality: A spatially explicit behavioral model of agricultural best management practices (DOCTORAL)

Wendong Zhang, Agricultural, Environmental, and Development Economics
Elena Irwin (Advisor), Agricultural, Environmental, and Development Economics

Many freshwater ecosystems around the world are severely compromised by elevated agricultural nutrient runoffs (phosphorus and nitrogen), which have substantially degraded water quality. In particular, many Lake Erie ecosystem services, such as recreational opportunities, are increasingly threatened by excessive agricultural runoffs in the Maumee River watershed. Changes in management practices will incur fundamental trade-offs by imposing costs on farmers but also generating benefits by improving multiple ecosystem service benefits, including water clarity, safe drinking water and recreational opportunities. However, these economic trade-offs are largely unknown due to the complexity of the economic and ecological linkages.

This project aimed to fill this knowledge gap by integrating economic and biophysical models and by quantifying the costs of upstream farm management changes and benefits of downstream ecosystem services in the Lake Erie region. Using a survey of 3,000 recreational anglers in Ohio, the research team demonstrated a significant economic value of ecosystem services provided by Lake Erie: Ohio anglers on average are willing to pay as much as $32–$88 if the lake conditions change from their current state plagued by harmful algal blooms to a clear state due to a 40 percent reduction in phosphorus loadings from Maumee, which in aggregate yields $3.2–$8.8 million dollars, assuming 10 percent of fishing trips are affected by HABs. Future work will broaden the value of ecosystem services by including the value of water clarity capitalized into lakefront property values, the value of clear beaches to beach-goers, and the value of safe drinking water and public health benefits. Ongoing work is also being done to help integrate the economic models of farmers' land use land management decisions with biophysical models that translate farmers' land management decisions to watershed-level phosphorus loadings and water quality conditions of the lake.

Participating Lead Faculty

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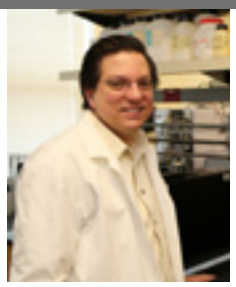

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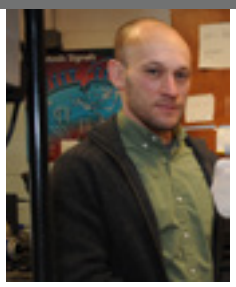

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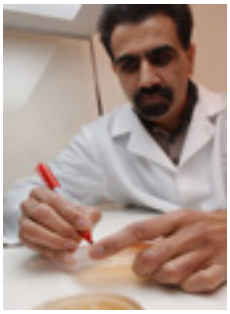

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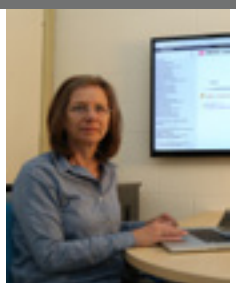

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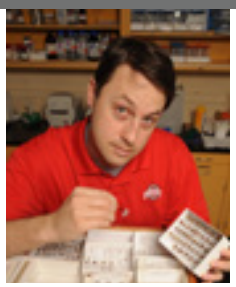

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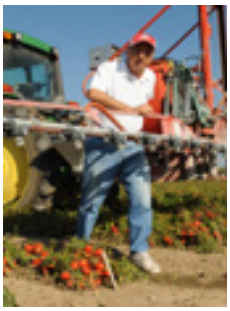

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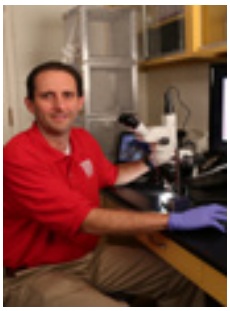

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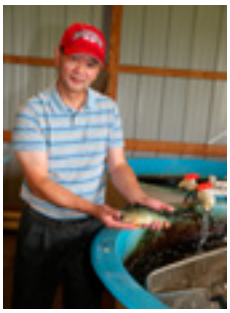

Hanping Wang
OSU South Centers

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